

What is claimed is:

1. A structure [for use as a portion of the sidewall of a space launch vehicle], comprising:

5 a first face sheet;

a second face sheet; and

10 a core sandwiched between the inside surfaces of said first and second face sheets, said core having at least a first thickness at a first longitudinal position and a second thickness at a second longitudinal position along the length of said composite structure, wherein the distance between the outside surfaces of said face sheets at said first and second positions is substantially equal.

15 2. The composite structure of Claim 1, wherein at least one of said first and second face sheets has a first thickness at said first longitudinal position and a second thickness at said second longitudinal position, wherein said first and second thickness are different.

20 3. The composite structure of Claim 1, wherein a first core thickness is utilized at said first longitudinal position and a second thinner core thickness is utilized at said second longitudinal position.

25 4. The composite structure of Claim 3, wherein at least one of said first and second face sheets have a corresponding increase in thickness at said second longitudinal position allowing the distance between the outside surfaces of said face sheets to remain equal at said first and second positions.

5. The composite structure of Claim 4, wherein said second longitudinal position is stiffer than said first longitudinal section.

6. The composite structure of Claim 5, wherein at least one end of said tubular structure is said second longitudinal position providing a stiffened end on said structure.

5 7. The composite structure of Claim 4, wherein said first and second face sheets each comprise a plurality of fiber reinforced material layers.

8. The composite structure of Claim 7, wherein at least one of said first and second face sheets has a first plurality of fiber reinforced material layers at said first longitudinal position and a second plurality of fiber reinforced material layers at said second longitudinal position, wherein said first and second pluralities are different.

9. The composite structure of Claim 8, wherein said fiber reinforced material layers are one of added to and removed from an inside surface of said face sheet.

10. The composite structure of Claim 3, wherein said first and second core thicknesses have first and second core densities, respectively.

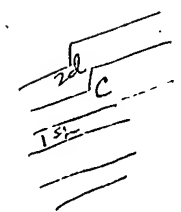
11. The composite structure of Claim 10, wherein said second longitudinal position, having the thinner core thickness, has a density greater than the core density at said first longitudinal position.

12. The composite structure of Claim 11, wherein said second longitudinal position has greater bearing and compressive strength than said first longitudinal position.

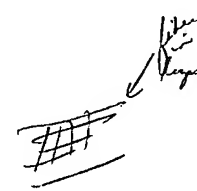
13. The composite structure of Claim 12, wherein at least one end of said tubular structure has a denser core providing an end on said structure having increased bearing and compressive strength.

Method of making
Claim 14 ref

14. A process for producing a structure for use as the sidewall for a portion of a space launch vehicle, said process comprising the steps of:
applying a first face sheet onto the outside surface of a mandrel;
covering the outside surface of said first face sheet with a core layer having at least a first and second thickness in at least a first and second position along the length of said mandrel;
applying second face sheet to the outside surface of said core layer,
wherein the combined thickness of said first face sheet, said core, and said second face sheet in said first and second positions is equal;
curing said composite structure; and
removing said mandrel.

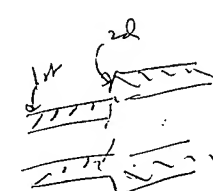


15. The process of Claim 14, wherein at least one of said applying steps further comprises applying a face sheet having a first thickness in said first position and a second thickness in said second position, wherein said first and second thickness are different.



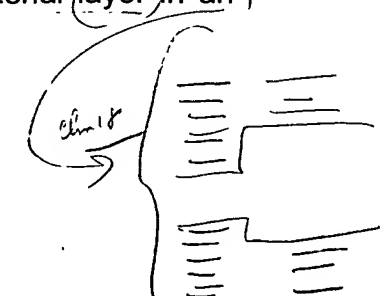
16. The process of Claim 15, wherein at least one of said first and second applying steps further comprises applying a plurality of fiber reinforced material layers.

17. The process of Claim 16, wherein at least one of said first and second applying steps further comprises applying a first plurality of fiber reinforced material layers in said first position and applying a second plurality of reinforced fiber material layers in said second position, wherein said first and second pluralities are different.



18. The process of Claim 17, wherein said step of applying said first and second plurality of fiber reinforced material layers further comprises one of increasing and decreasing said plurality of reinforced fiber material layer in an inverse relationship with changes in thickness of said core.

No art
(plurality of layers?)



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19. The process of Claim 18, wherein increasing and decreasing said fiber reinforced material layers further comprises one of adding and subtracting fiber reinforced material layers from the inside surfaces of at least one of said first and second faces sheets.

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20. The process of Claim 14, wherein said covering step further comprises utilizing a core having at least a first position along the length of the mandrel with a reduced thickness in comparison with at least a second position along the length of said mandrel.

face
core

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21 The process of Claim 20, wherein said applying steps further comprises applying at least one face sheet having an increased thickness in said first position such that the combined thickness of said first face sheet, said core, and said second face sheet in said first and second positions is equal.

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for density
you

22. The process of Claim 20, wherein said covering step further comprises utilizing a core having an increased density at said first position.

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23. The process of Claim 14, wherein said first and second applying steps comprise at least one of hand lay-up, filament winding, and fiber placement.

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24. The process of Claim 23, wherein pre-impregnated fiber reinforced materials are utilized.

Method
Designing

25. A method for designing a multi-layered structure having at least one reinforced portion, said method comprising the steps:

determining a spatial envelope for said multi-layered structure;

identifying a portion of said structure for reinforcement; and

based on the constraints of said spatial envelope, altering one of a material property and a dimension of at least one of said layers at said portion to be reinforced relative to another portion of said structure so as to provide the desired reinforcement free from any exterior irregularity associated with said reinforcement.

26. The method of Claim 25, wherein said step of determining further comprises determining a maximum allowable thickness at said portion for reinforcement, said thickness defined by the outermost surface of an outermost layer of said multi-layered structure and the innermost surface of an innermost layer of said multi-layered structure.

27. The method of Claim 25, wherein said step of identifying further comprises determining at least a first structural requirement associated with said portion for reinforcement.

28. The method of Claim 27, wherein said determining at least a first structural requirement step comprises determining at least one of a tensile strength, a compressive strength, a stiffness, a bearing strength and a tearing strength.

29. The method of Claim 25, wherein said step of altering comprises altering the relative thicknesses of at least two of said layers at said portion for reinforcement in comparison to the relative thicknesses of said at least two layers at a non-reinforced portion of said structure.

30. The method of Claim 25, wherein said step of altering the relative thicknesses of at least two layers comprises reducing the thickness of at least a first layer and correspondingly increasing the thickness of at least a second layer, wherein the thickness of said structure defined by the outermost surface of an outermost layer of said structure and the innermost surface of an innermost layer of said structure at said reinforced portion and non-reinforced portion is equal.

31. A composite structure having variable structural properties, said structure comprising

a first outermost layer;

a second innermost layer;

at least one core layer between said first and second layers, wherein said first layer, second layer and core layer define a composite structure having an overall thickness defined at any portion thereof by the outermost surface of the outermost layer and the innermost surface of the innermost layer; and

said composite structure having a variation between a first set of structural properties at a first portion and a second set of structural properties at a second portion, wherein said variation is at least partially based on the relative thicknesses of said first layer, second layer and core layer at said sections independent of an overall thickness of said composite structure.

32. The structure of Claim 31, wherein at least one of said first outermost layer and said second innermost layer further comprise a plurality of fiber reinforced material layers.

33. The structure of Claim 31, wherein at least one of said first outermost layer and said second innermost layer has a first thickness at said first portion and a second thickness at said second portion.

34. The structure of Claim 33, wherein said core has a first thickness at said first portion and a second thickness at said second portion.

35. The structure of Claim 34, wherein the overall thickness of said first outermost layer and said second innermost layer and said core at said first and second portions is equal.

36. The structure of Claim 35, wherein said relative proportions of said first outermost layer and said second innermost layer and said core at said first and second portions produce one portion having enhanced structural properties in comparison with the other said portion.

37. The structure of Claim 35, wherein said enhanced portion has at least one of an increased tensile strength, an increased compressive strength, an increased stiffness, an increased bearing strength and an increased tearing strength.

38. The structure of Claim 31, wherein said variation is at least partially based on the material properties of said first layer, second layer and core layer at said first and second portions.

39. The structure of Claim 38, wherein at least one of said first layer, second layer and core layer have varying material properties between said first and second sections.

40. The structure of Claim 38, wherein at least one of said first layer and said second further comprise a plurality of fiber reinforced material layers, wherein the composition of said plurality of fiber reinforced material layers varies between said first and second portions.

41. The structure of Claim 38, wherein the material properties of said core vary from said first and second portions.